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JAPANESE RESEARCH AND DEVELOPMENT: AN ERA OF "TECHNOGLOBALISM"

SUMMARY

By most statistical measures Japanese research and development remains extremely healthy and vigorous. Spending growth is strong and widespread through Japanese industry and government. When evaluated by new self-proclaimed measures of international cooperation and participation, however, Japan's R&D policies come up short. The debate among Japanese science policymakers and business leaders over the direction of the nation's research policies involves important consequences for the international community as well as domestic companies. Whether "technoglobalism," the emphasis on the international pursuit and sharing of technology and research, is the right answer to the new demands being placed on Japan is a key part of this debate.

Introduction

Japan's private and government research and development planners are finding that pledging a level of global science and technology contributions that reflect the nation's economic strength is easier than actually accomplishing this. Policies aimed at developing new know-how already are in place; now Tokyo is drawing up and implementing plans to share technology with not only developed but developing countries. Steps that go beyond the existing policy of opening Japan's R&D programs to foreign participation include eliciting foreign input at the planning stage of government projects. Japanese policymakers anticipate that the continued expansion of Japan's global R&D contributions will require a boost in overall spending and a need to address new priorities and roles.

Similar tasks face Japan's private sector, the driving force behind the nation's leap to the leading edge of industrial technology. In an era of deregulation government officials find they have fewer levers to encourage companies to be more generous and open-minded with regard to technology transfer to potential foreign competitors. Nevertheless, economic, business and technological forces are driving Japanese firms to reconsider their technology policies, perhaps signaling a new age of

"technoglobalism." This term, coined in Japanese circles, indicates the borderless pursuit of scientific and technical research with the participation of governments as well as companies worldwide.

Spending Fest Continues

The latest government review of total R&D spending in Japan showed a 10.7 percent increase to ¥13.1 trillion (\$97 billion at ¥135=\$1.00) in the year ending March 31, 1991 (see Table 1a). FY 1990's gain represented the second consecutive double-digit performance, marking an end to the FY 1986-FY 1988 slowdown in the growth of R&D spending. Yet, since Japanese R&D spending clearly is influenced by the pace of overall economic activity, it will be interesting to compare the impact of the current recession on R&D spending with the record of the FY 1986-FY 1988 period. Reports to date point to somewhat lower rates of growth, at least by industry.

Spending by Organization - The corporate sector stretched its lead in FY 1990 with a 12.6 percent gain to nearly ¥9.3 trillion (\$68.6 billion). The FY 1990 showings by universities and research institutions were better than the previous year (but only by a fraction in the latter case). The acceleration of R&D spending by universities to a recent high is encouraging news for basic research in Japan, since much fundamental science work takes place in the academic community. Whether the relatively low level of growth in research institutions' spending (compared to the boom years of FY 1985 and FY 1987) signals a structural shift in expenditure patterns or simply is within normal variations requires more years of data. Funding for research institutes depends on the whims of corporate and government budget planners; that complicates an analysis of how or if their role is changing.

Funding Sources - The private sector maintained an easy lead in FY 1990 as the primary source of R&D funding (Table 1b); in fact, its share of total financing increased again. The 11.6 percent expansion in corporate outlays was healthy but, since growth was less than the 13 percent jump the year before, may indicate a reappraisal of priorities. Public R&D funds grew 6.5 percent in FY 1990, the second consecutive solid improvement over the previous fiscal year and an above-average gain compared with the late 1980s. Still, this growth did not return the government's share of total R&D funding to the 20 percent-plus level of the years prior to FY 1988; in fact, the 17.9 percent figure represented a new low share for the second consecutive year. The government's R&D budget clearly has not been safe from the Ministry of Finance's fiscal austerity axe, but the planned gain in government R&D spending for the current fiscal year is an encouraging sign that Tokyo takes seriously its new commitment to make Japan a global technology source.

Funding by Purpose - For the third year in a row data on Japanese R&D by purpose cast doubt on at least corporate Japan's willingness to become a source of basic research knowledge. While the share of money for developmental work, which leads directly to commercial products, held steady in FY 1990, the proportion allotted to basic research edged back (see Table 2). That basic research lost while applied research gained a similar percentage share is small consolation to observers concerned that Japan is pulling back from basic research in favor of commercialization as global economic competition heats up.

Data broken down by purpose by spending organization reveals a surprising story behind the above trend (see Table 3). One might expect that the dominant role of private R&D spending in Japan would lie at the root of the waning financial attention given basic research. Despite the supposed long-term outlook and patience of Japanese management, R&D spending still must be justified by bottom-line results. Accordingly, private R&D spending tends toward commercial applications. Thus, it would not be surprising if overall spending moved in this direction, since the private sector accounts for the majority of Japanese R&D spending and shows the highest growth rate. The breakdown of

Table 1: Japan's R&D Expenditures, FY 1985-FY 1990

(in billions of yen and percent)

a. By Spending Organization

<u>Fiscal Year</u>	<u>Companies</u>	<u>Research Institutions</u>	<u>Universities</u>	<u>Total</u>
1985	¥5,939.9	¥1,160.6	¥1,789.8	¥8,890.3
Change	15.6%	12.3%	3.8%	12.6%
Share	66.8%	13.1%	20.1%	100.0%
1986	6,120.2	1,240.2	1,832.6	9,192.9
Change	3.0%	6.9%	2.4%	3.4%
Share	66.6%	13.5%	19.9%	100.0%
1987	6,494.3	1,384.5	1,957.9	9,836.6
Change	6.1%	11.6%	6.8%	7.0%
Share	66.0%	14.1%	19.9%	100.0%
1988	7,219.3	1,394.2	2,014.1	10,627.6
Change	11.2%	0.7%	2.9%	8.0%
Share	67.9%	13.1%	19.0%	100.0%
1989	8,233.8	1,452.3	2,129.4	11,815.5
Change	14.1%	4.2%	5.7%	11.2%
Share	69.7%	12.3%	18.0%	100.0%
1990	9,267.2	1,514.2	2,297.0	13,078.3
Change	12.6%	4.3%	7.9%	10.7%
Share	70.9%	11.6%	17.6%	100.0%

b. By Source of Funds

<u>Fiscal Year</u>	<u>Government</u>	<u>Private</u>	<u>Foreign</u>	<u>Total</u>
1985	¥1,867.3	¥7,014.9	¥8.1	¥8,890.3
Change	5.0%	14.8%	6.6%	12.6%
Share	21.0%	78.9%	0.1%	100.0%
1986	1,955.3	7,229.7	7.9	9,192.9
Change	4.7%	3.1%	-2.5%	3.4%
Share	21.5%	78.4%	0.1%	100.0%
1987	2,111.8	7,716.6	8.2	9,836.6
Change	8.0%	6.7%	3.8%	7.0%
Share	21.5%	78.4%	0.1%	100.0%
1988	2,117.8	8,501.5	8.3	10,627.6
Change	0.3%	10.2%	1.2%	8.0%
Share	19.9%	80.0%	0.1%	100.0%
1989	2,202.4	9,603.3	9.7	11,815.5
Change	4.0%	13.0%	16.7%	11.2%
Share	18.6%	81.3%	0.1%	100.0%
1990	2,346.6	10,721.5	10.3	13,078.3
Change	6.5%	11.6%	6.2%	10.7%
Share	17.9%	82.0%	0.1%	100.0%

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

Table 2: Japan's Research Expenditures by Purpose, FY 1985-FY 1990

(in billions of yen and percentage share)

<u>Fiscal Year</u>	<u>Basic Research</u>	<u>Applied Research</u>	<u>Developmental Research</u>
1985	¥1,030.6 12.9%	¥2,001.8 25.0%	¥4,985.9 62.2%
1986	1,102.8 13.3%	2,030.8 24.4%	5,185.0 62.3%
1987	1,250.2 14.0%	2,166.8 24.3%	5,497.3 61.7%
1988	1,288.0 13.3%	2,346.6 24.3%	6,041.0 62.4%
1989	1,390.9 12.8%	2,588.4 23.9%	6,848.0 63.2%
1990	1,510.2 12.6%	2,906.1 24.2%	7,577.2 63.2%

Source: Management and Coordination Agency, *Report on the Survey of Research and Development*.

Table 3: Japan's Research Expenditures by Spending Organization by Purpose, FY 1985-FY 1990

(share of each organization's total expenditures in percent)

<u>Fiscal Year</u>	<u>Basic Research</u>	<u>Applied Research</u>	<u>Developmental Research</u>
1985			
Universities	54.2%	37.4%	8.4%
Research Institutions	12.3	30.0	57.7
Companies	5.9	21.9	72.1
1986			
Universities	54.2	37.4	8.4
Research Institutions	13.8	27.4	58.8
Companies	6.1	21.6	72.3
1987			
Universities	54.2	37.4	8.4
Research Institutions	15.8	26.0	58.2
Companies	6.6	21.7	71.7
1988			
Universities	52.8	38.5	8.7
Research Institutions	14.9	25.4	59.7
Companies	6.6	21.7	71.7
1989			
Universities	53.2	38.1	8.7
Research Institutions	15.3	25.7	59.0
Companies	6.4	21.5	72.2
1990			
Universities	52.9	38.4	8.7
Research Institutions	15.7	26.6	57.7
Companies	6.4	21.8	71.8

Source: Management and Coordination Agency, *Report on the Survey of Research and Development*.

corporate work among basic, precommercial (applied) and commercial research, however, shows that companies allocated the *same* share of funds to basic R&D in FY 1990 as the year before. Research institutions put more of their money into basic work. Universities, however, cut their share by several tenths of a percentage point. Interestingly, these funds were shifted to applied research rather than developmental research, an area one might expect universities to place ahead of commercial applications.

Government Spending

Japanese budget planners continue to present as conventional wisdom the theme of fiscal austerity, the Ministry of Finance's chief weapon since the early 1980s against the burgeoning national debt (see *JEI Report* No. 16A, May 24, 1992). While MOF was able to keep a lid on new spending through the mid-1980s, its grip has loosened as greater domestic and international expectations have been placed on Japan. Supporting research clearly is important to Tokyo, but this category does not enjoy *carte blanche*. Table 4 shows that the growth of research outlays merely has kept pace with the expansion of total spending (its share has varied only marginally). Government-funded R&D has expanded faster, however, than discretionary spending.

Table 4: Research Expenditures as Share of General Account Budget, FY 1985-FY 1992

(revised budgets in billions of yen and percent)

a. As Share of Total Expenditures

<u>Fiscal Year</u>	<u>Total Expenditures</u>	<u>Research Expenditures</u>	<u>Share</u>
1985	¥53,222.9	¥1,521.6	2.9%
1986	53,824.8	1,599.0	3.0
1987	58,241.2	1,655.0	2.8
1988	61,851.7	1,715.7	2.8
1989	66,311.9	1,814.8	2.7
1990	69,651.2	1,920.9	2.8
1991	70,347.4	2,022.6	2.9
1992*	72,218.0	2,134.7	3.0

b. As Share of Discretionary Expenditures

<u>Fiscal Year</u>	<u>Total Expenditures</u>	<u>Research Expenditures</u>	<u>Share</u>
1985	¥33,352.3	¥1,521.6	4.6%
1986	33,425.7	1,599.0	4.8
1987	35,276.5	1,655.0	4.7
1988	36,789.8	1,715.7	4.6
1989	39,257.4	1,814.8	4.6
1990	39,271.0	1,920.9	5.0
1991	39,276.7	2,022.6	5.1
1992*	39,998.8	2,134.7	5.3

*Initial budget.

Source: Ministry of Finance

FY 1992 data on government R&D spending by agency appears to present a mixed bag of gains, with at least one hefty loss (see Tables 5 and 6). Overall R&D spending growth for the current fiscal year initially is budgeted 5.5 percent higher, greater than FY 1991's final gain of 5 percent. For the second consecutive year the direction of spending in FY 1992 is evenly upward (compared with FY 1991's initial increases), with a notable exception. The significant cut at the Ministry of Labor, one of the three organizations receiving less money in the current fiscal year, means it initially at least has lost in FY 1992 all that it gained in FY 1991 and then some; its total R&D budget rose from just under ¥4.2 billion (\$31.1 million) in FY 1990 to ¥5 billion-plus (\$37 million) before plunging to ¥3.8 billion (\$28.1 million). The Ministry of Education's 1.5 percentage-point improvement over FY 1991 may signal its successful campaign with MOF for funds to upgrade research facilities at the nation's universities and to bolster basic research, a goal that requires a sustained effort. Perhaps signaling a growing response to international responsibilities, the Ministry of Foreign Affairs' R&D budget is up 15 percent, although much of this money goes for administrative bodies, such as the International Atomic Energy Agency and other research-related multilateral organizations.

For most agencies, though, FY 1992 cannot be seen as an extraordinarily prosperous year. Among those seeing growth rates shrink were the Ministry of Transportation and the Environment Agency. (See *JEI Report No. 36A*, September 27, 1991 for full details on the previous year's figures.) Thanks to a growth rate of 10.4 percent in FY 1992 the Japan Defense Agency appears to be on its way toward its policy goal of doubling R&D's share of its budget from 2.5 percent to 5 percent by FY 1995, but the end of the Cold War and new prospects for warmer relations between Japan and the former Soviet Union still could dampen the pace of defense-related R&D in future years.

A clearer picture of each agency's priorities can be seen from FY 1991-FY 1992 spending plans (see Table 7). Basic research has its ups and downs in FY 1992, sometimes within the same ministry. For example, while the Education Ministry's overall FY 1992 R&D budget shows a 6 percent gain, funds for university research are up 6.1 percent, but grants for national university researchers will expand only 2.4 percent. Nonetheless, one of the major themes in Japan's basic research program — internationalism, either inviting foreign researchers to come to Japan or forming joint projects to carry out research around the globe — appears to be gaining strength. Programs with an international flavor and increased funding levels include: the Human Frontiers Science Program funded by the Science and Technology Agency and the Ministry of International Trade and Industry, plus MITI's nuclear energy and energy conservation programs.

Government-sponsored environmental research programs present a mixed picture in FY 1992, contrasting sharply with their uniform growth in FY 1991 and perhaps raising questions about Tokyo's sincerity on its environmental commitments. STA, for example, is sharply hiking funds for its Green Planet Project but is cutting outlays for other environmental programs. Moreover, many of the Environment Agency's research projects linked to international issues have gained greater funding this fiscal year, but strictly domestic programs have not fared as well. Although the Environment Agency clearly is devoting more money to environmental programs, its activities fund only a small piece of Japan's environmental R&D. Other agencies, though, are in the early stages of assembling environmental programs, as shown by the R&D budgets for the Ministry of Posts and Telecommunications and the Ministry of Construction.

Overall, public R&D spending continues to focus funds on developing precommercial know-how, an approach that many observers credit for Japan's economic growth. Areas in which corporate Japan is unlikely to risk bearing the full costs on its own, such as space development, are receiving greater emphasis from the government. Its FY 1992 budget also clearly signals increased support for basic and international research ("international" in that it either involves foreign participation or is aimed at global issues). Tokyo appears to be building an institutional framework to channel the flow of government R&D spending into new areas. The success or failure of these efforts, however, is not dependent on funding alone. Support from the private sector and foreign countries will be important factors.

Table 5: Japanese Government R&D Expenditures, Revised FY 1991

(in millions of yen and percentage change)

	<u>Science Promotion</u>	<u>Energy and Other Research</u>	<u>Special Research*</u>	<u>Total</u>
Diet	¥519 -0.8%	¥0 —	¥0 —	¥519 -0.8%
Japan Technology Council	0 —	1,051 10.5%	0 —	1,051 10.5%
Police Agency	1,133 3.4%	0 —	0 —	1,133 3.4%
Hokkaido Development Agency	141 -2.1%	0 —	0 —	141 -2.1%
Defense Agency	0 —	115,045 10.3%	0 —	115,045 10.3%
Economic Planning Agency	850 5.1%	0 —	0 —	850 5.1%
Science and Technology Agency	220,600 8.3%	165,575 0.4%	133,045 6.5%	519,220 5.2%
Environment Agency	10,527 15.2%	0 —	0 —	10,527 15.2%
Justice Ministry	989 4.1%	0 —	0 —	989 4.1%
Foreign Ministry	0 —	3,160 15.0%	0 —	8,160 15.0%
Finance Ministry	388 4.0%	0 —	811 11.2%	1,199 8.8%
Education Ministry	73,566 1.1%	131,030 0.9%	728,718 5.7%	933,314 4.6%
Health Ministry	41,894 7.9%	2,159 63.7%	11,707 5.5%	55,760 8.8%
Agriculture Ministry	66,832 2.3%	2,807 6.2%	3,300 0.0%	72,939 2.5%
International Trade and Industry Ministry	55,934 -0.1%	13,843 4.4%	185,605 1.6%	255,382 2.1%
Transportation Ministry	13,498 23.8%	5,926 79.0%	1,145 11.0%	20,569 17.3%
Posts and Telecommunications Ministry	5,086 11.5%	232 22.6%	28,600 10.0%	33,918 8.4%
Labor Ministry	666 5.2%	6 -83.6%	4,367 24.0%	5,039 20.2%
Construction Ministry	5,887 3.9%	732 61.2%	0 —	6,619 8.9%
Home Affairs Ministry	604 3.8%	0 —	0 —	604 3.8%
Total	499,116 5.3%	446,565 4.2%	1,068,698 5.1%	2,014,379 5.0%

*Column adds to more than the total because of double-counting of budgets for projects shared by more than one agency.

Source: Japan Society for the Promotion of Science, *Japanese Scientific Monthly*, July 1992.

Table 6: Japanese Government R&D Expenditures, Initial FY 1992

(in millions of yen and percentage change)

	<u>Science Promotion</u>	<u>Energy and Other Research</u>	<u>Special Research*</u>	<u>Total</u>
Diet	¥536 0.6%	¥0 --	¥0 --	¥536 0.6%
Japan Technology Council	0 --	1,042 -0.8%	0 --	1,042 -0.8%
Police Agency	1,209 5.7%	0 --	0 --	1,209 5.7%
Hokkaido Development Agency	150 1.4%	0 --	0 --	150 1.4%
Defense Agency	0 --	126,989 10.4%	0 --	126,989 10.4%
Economic Planning Agency	930 9.4%	0 --	0 --	930 9.4%
Science and Technology Agency	246,208 9.9%	165,657 0.0%	139,912 5.2%	551,778 5.6%
Environment Agency	11,847 8.7%	0 --	0 --	11,847 8.7%
Justice Ministry	1,063 5.7%	0 --	0 --	1,063 5.7%
Foreign Ministry	0 --	8,251 1.1%	0 --	8,251 1.1%
Finance Ministry	407 6.6%	0 --	1,028 26.7%	1,434 20.3%
Education Ministry	84,899 10.9%	134,189 2.4%	773,020 6.1%	992,108 6.0%
Health Ministry	47,234 11.7%	1,864 -13.7%	12,240 4.6%	61,338 9.3%
Agriculture Ministry	69,935 3.7%	2,942 4.8%	3,300 0.0%	76,177 3.6%
International Trade and Industry Ministry	56,205 -0.5%	14,066 1.6%	188,951 1.8%	259,223 1.3%
Transportation Ministry	14,436 7.4%	6,944 17.2%	1,135 -0.9%	22,515 9.8%
Posts and Telecommunications Ministry	5,289 4.3%	444 91.4%	27,000 -5.6%	32,733 -3.5%
Labor Ministry	699 3.9%	6 1.0%	3,082 -29.4%	3,787 -24.9%
Construction Ministry	6,150 4.4%	786 7.3%	0 --	6,936 4.7%
Home Affairs Ministry	631 2.4%	0 --	0 --	631 2.4%
Total	547,289 8.0%	463,180 3.7%	1,123,667 5.1%	2,134,676 5.5%

*Column adds to more than the total because of double-counting of budgets for projects shared by more than one agency.

Source: Japan Society for the Promotion of Science, *Japanese Scientific Monthly*, July 1992.

Table 7: Expenditures on Selected Science Programs by Agency, FY 1991-FY 1992

(in millions of yen)

	<u>FY 1991</u>	<u>FY 1992</u>
Japan Defense Agency		
Technology development	¥115,045	¥125,880
Science and Technology Agency		
Promotion of innovative and basic technology	10,127	11,201
Green Planet Project (global warming)	10,306	18,855
Human Frontiers Science Program	2,194	2,284
Science and technology promotion	14,397	16,012
Science policy administration	11,189	11,721
Nuclear energy research	306,435	315,230
Outerspace research	131,769	144,642
Ocean technology development	10,666	11,400
Environmental, planetary research	35,662	31,648
Materials research	13,548	14,099
Life sciences research	18,976	21,350
Environment Agency		
National Environment Research Institute	5,977	6,359
Global environmental research	1,700	1,900
National Disaster Prevention Institute	1,928	1,918
Foreign Ministry		
International agricultural research group	3,385	3,475
OECD Nuclear Power Committee	324	328
Education Ministry		
Environmental research	33,472	39,517
Japan Technology Promotion Council grants	6,661	7,657
University research programs	728,718	773,020
National university research grants	131,029	134,189
Health Ministry		
Agency research	16,926	19,367
Research grants	20,391	22,062
Pharmaceutical research	2,300	2,300
Health science research	7,426	8,520
Cancer research projects	3,352	3,694
International cancer research	176	165
Medical and drug information system	149	149
Agriculture Ministry		
Agency research	57,330	59,272
Basic research	3,766	3,924
International cooperation	467	509
Private industry support	814	890
Regional development programs	2,485	2,524
Environmental research	146	147
Tropical agriculture research	716	776
Food product technology	642	625
International Trade and Industry Ministry		
Large-scale industrial technology projects	10,998	12,057
Basic computer technology development	5,041	5,809
Basic Technology Promotion Center	28,600	26,000
Next-generation basic technology projects	7,869	8,157
New energy technology development projects	24,817	25,779
Energy conservation projects	11,487	11,517
Nuclear energy development projects	28,724	27,971
Human Frontiers Science Program	1,515	1,552
International aircraft development	3,670	4,310
Global Environment Industrial Technology Institute	6,748	7,930
Small business technology improvement	6,495	6,135
Transportation Ministry		
Agency research (including five ship technology centers)	8,554	9,077
Weather satellite programs	2,946	3,414
Magnetic levitation train technology	4,705	5,704
Next-generation ship technology	936	955
Posts and Telecommunications Ministry		
Electrotechnical laboratories	5,072	5,289
Communications Frontier Research	470	577
Space communications	942	956
Environmental projects	119	145
Basic Technology Promotion Center	28,600	26,000
Labor Ministry		
Agency research	3,152	3,082
Industrial safety research	2,043	603
Japan Bioassay Research Center	1,363	1,378
Construction Ministry		
Agency research (including one engineering center)	5,055	5,194
Construction technology research	765	793
Environmental projects	49	n.a.

Source: Japan Society for the Promotion of Science, *Japanese Scientific Monthly*, July 1992.

Private Spending

The data in Tables 1 and 2 confirm the dominant role of private R&D in Japan. Companies outspent the government by more than 4-to-1 in FY 1990, as intense competition — both domestic and foreign — stimulated Japanese industry to adopt a strong technology development program. Historical data indicate that corporate R&D spending is not immune completely when company bean counters trim budgets, but R&D items have been spared from heavy cutbacks during earlier economic downturns because such spending is considered crucial to a firm's future. Nevertheless, many firms are taking a hard look at their research budgets as part of a general reassessment of their business strategies. A new emphasis on coexistence and "symbiosis" (to use the current Japanese buzzword) with foreign competitors as well as a reconsideration of the balance between profits and market share have blunted the edge of the private sector's all-out assault on advanced research. This reappraisal of investment strategies has been particularly noticeable with the fall of the Tokyo stock market and the higher cost of raising new funds.

Although the latest government data on private R&D predate the current slump, they reveal that halving of year-to-year growth rates in some industry sectors is as common as doubling funding from one year to the next in others (see Table 8). The reasons for these swings are not apparent from the survey data, and there is no obvious pattern in the gains and cutbacks that might arise from macroeconomic factors. This patchy performance calls into question the common view that Japanese companies exhibit a long-term, steady commitment to R&D. While this may be true for certain firms, it clearly is less compelling at the industry level. Nevertheless, companies in industries where Japanese competitors are recognized as world leaders reflect a solid commitment to R&D spending. Examples include parts of the textile, chemicals, nonelectric machinery, electronics and transportation equipment industries. Faced with challenges at the upper end of their markets by firms from advanced industrialized countries and at the lower end by companies based in rapidly developing Asian nations, Japanese corporations understand that they will be passed if they stand still.

Not surprisingly, the mixed picture of increases and reductions carries over when corporate R&D spending is expressed as a share of gross sales (see Table 9). While all industries recorded a higher R&D-to-gross sales ratio in FY 1990 than a decade previously, a comparison of FY 1989 and FY 1990 data shows that the movement is not inexorably upward. Again, the government survey does not reveal the reasons for the declines; nor is any pattern apparent.

Since the private sector is the hotbed of R&D activity in Japan, companies not surprisingly are under increasing international pressure to share their technology. Corporate Japan is faced with two demands: increase funding for basic research (which traditionally has been considered a public commodity) and transfer more technology to foreign partners. As mentioned above, the business sector put more money in FY 1990 into applied research at the expense of developmental purposes while keeping funding for basic work steady. Table 10 shows that while the overall figures may have moved in one direction, not all industries followed that move. Some major industries reported gains of about 2 percentage points or more in funding for basic research, such as food products, plastics and steel. Among those showing reductions were chemicals, including pharmaceuticals, plus electric machinery and transportation equipment. As for developmental research, 16 of the 26 separately classified industries cut this category of spending, eight increased outlays and two kept them unchanged. Industries increasing spending for applied research outnumbered those cutting funding by a margin of 18 to seven, with one remaining the same.

Technology Trade

The international community continues to have the highest expectations of Japanese science in the area of technology trade. When country-to-country talks produce requests for greater technology transfers, Tokyo points out that the private sector needs to be a factor in such discussions. With the private sector exercising the leading role in Japanese R&D, much of the most desirable

technology for transfer abroad continues to be in private, not government, hands. Companies understandably are loathe to disclose to competitors any discoveries or potentially important know-how, and they are even less inclined to do so without adequate compensation. While advanced nations may feel Japan is indebted to them for relatively unlimited access to their technology, Japanese manufacturers argue that their technological achievements are due as much to their own efforts as to foreign help. In addition, these companies maintain that their technology-gathering was aboveboard and paid for through licensing fees and royalties. Nevertheless, at the government level officials have committed Japan to becoming a net contributor of technology, particularly to developing nations.

Table 8: Japan's R&D Expenditures by Industry, FY 1989-FY 1990

(in billions of yen and percentage change)

	FY 1989		FY 1990	
	Total	Change	Total	Change
Agriculture	¥4.4	-46.3%	¥10.9	146.2%
Mining	24.6	-12.5	29.7	20.9
Construction	185.1	24.7	212.7	14.9
Manufacturing	7,706.2	14.1	8,660.3	12.4
Food Products	203.6	13.5	217.5	6.8
Textiles	81.3	11.6	88.3	8.6
Pulp and Paper	45.5	6.3	48.6	6.8
Publishing and Printing	33.7	33.0	37.7	11.7
Chemicals	1,313.9	10.4	1,416.8	7.8
Industrial Chemicals and				
Synthetic Fibers	552.0	10.1	587.4	6.4
Oils and Paints	134.5	15.6	139.1	3.4
Pharmaceuticals	456.0	9.5	516.1	13.2
Other	171.4	9.7	174.2	1.6
Petroleum and Coal Products	84.2	12.3	92.0	9.2
Plastic Products	120.8	32.8	111.7	-7.5
Rubber Products	111.8	10.1	117.9	5.5
Nonmetallic Mineral Products	221.4	11.5	215.3	-2.8
Steel	268.1	7.4	303.8	13.3
Nonferrous Metals	127.0	5.6	140.7	10.7
Fabricated Metal Products	109.3	22.0	129.6	18.6
Nonelectric Machinery	559.0	23.9	650.3	16.3
Electric Machinery	2,808.1	14.5	3,146.3	12.0
Communications and Electronics				
Equipment	1,941.7	13.6	2,150.0	10.7
Other	866.4	16.8	996.2	15.0
Transportation Equipment	1,244.6	14.6	1,496.1	20.2
Motor Vehicles	1,087.2	16.6	1,295.6	19.2
Other	157.4	2.2	200.5	27.4
Precision Machinery	266.1	11.5	335.8	26.2
Other	107.8	18.7	112.1	4.1
Transportation, Communications				
and Utilities	313.5	12.0	353.6	12.8
Total	8,233.8	14.1	9,267.2	12.6

Source: Management and Coordination Agency, *Report on the Survey of Research and Development*.

The latest government data on technology flows indicate that Japan has lost some ground in its drive to achieve this goal. Total exports and imports alone tell less than a look at new technology transactions and their value (see Tables 11 and 12). Japan long has exported more new technology (which excludes payments or renewals of previous deals) than it imports, but the value of this technology has been erratic. When viewed from Japan's attempts to encourage technology transfers, however, the transactions in both new and overall exports dropped between FY 1989 and FY 1990, as did the value of new exports (but not the overall value).

Table 9: Japan's Ratio of Corporate R&D Expenditures to Gross Sales by Industry, FY 1980-FY 1990

(in percent)				
Industry	FY 1980	FY 1985	FY 1989	FY 1990
Agriculture	0.17%	0.24%	0.21%	0.50%
Mining	0.52	1.03	0.94	1.13
Construction	0.46	0.49	0.52	0.54
Manufacturing	1.73	2.69	3.29	3.36
Food Products	0.58	0.77	1.07	0.98
Textiles	0.77	1.18	1.71	1.76
Pulp and Paper	0.41	0.71	0.79	0.88
Publishing and Printing	0.26	0.68	0.71	0.88
Chemicals	2.55	3.79	4.84	4.89
Industrial Chemicals and				
Synthetic Fibers	1.85	2.80	4.09	4.01
Oils and Paints	2.48	3.14	3.93	3.90
Pharmaceuticals	5.45	7.04	7.50	8.02
Other	2.19	3.61	4.11	4.06
Petroleum and Coal Products	0.30	0.38	0.72	0.64
Plastic Products	n.a.	1.75	2.73	2.37
Rubber Products	2.10	2.86	3.25	3.20
Nonmetallic Mineral Products	1.30	2.61	2.75	2.60
Steel	1.14	1.94	2.21	2.33
Nonferrous Metals	1.03	1.92	1.91	1.80
Fabricated Metal Products	1.15	1.59	1.36	1.60
Nonelectric Machinery	1.90	2.74	2.83	2.99
Electric Machinery	3.71	5.10	5.89	5.86
Communications and Electronics				
Equipment	3.94	5.25	6.10	6.12
Other	3.35	4.82	5.47	5.36
Transportation Equipment	2.34	2.90	3.40	3.65
Motor Vehicles	2.38	2.96	3.48	3.73
Other	2.15	2.61	2.93	3.20
Precision Machinery	3.02	4.49	5.16	5.94
Other	1.16*	0.97	1.19	1.21
Transportation, Communications and Utilities	0.32	0.98	1.06	1.07
All Industry Average	1.48	2.31	2.72	2.78

*Includes plastic products.

Source: Management and Coordination Agency, *Report on the Survey of Research and Development*.

FY 1990 was a banner year for renewing previous technology import agreements; the total number of import transactions (renewals plus new) rose sharply, while the number of new import contracts fell. Although this import surge produced the expected boost in the total value of import contracts, the sharp increase in the cost of new import agreements indicates that each contract, or perhaps several key contracts, carried a significantly robust royalty. The opposite situation appeared to exist on the export side. The total number of contracts fell but their value rose, while the total number of new agreements and their value both dropped. American companies have been defending

Table 10: Japan's Corporate R&D Expenditures by Purpose, FY 1989-FY 1990

(in percent of total sectoral spending)

Industry	Basic Research		Applied Research		Developmental Research	
	1989	1990	1989	1990	1989	1990
Agriculture	8.8%	14.4%	30.9%	34.8%	60.3%	50.8%
Mining	17.0	16.9	28.1	31.9	54.9	51.2
Construction	6.1	6.5	22.8	24.1	71.1	69.4
Manufacturing	6.4	6.3	21.0	21.2	72.6	72.5
Food Products	12.1	14.0	32.3	30.4	55.6	55.6
Textiles	6.1	7.2	26.9	27.0	67.0	65.7
Pulp and Paper	4.2	5.8	26.0	36.2	69.8	58.0
Publishing and Printing	5.9	3.6	45.3	50.7	48.8	45.7
Chemicals	13.7	12.8	27.8	28.5	58.5	58.8
Industrial Chemicals and Synthetic Fibers	10.7	9.1	30.0	32.0	59.4	58.9
Oils and Paints	4.4	5.2	33.3	31.2	62.2	63.5
Pharmaceuticals	20.9	19.6	26.8	27.4	52.3	53.0
Other	11.4	10.9	19.1	17.3	69.5	71.8
Petroleum and Coal Products	11.1	12.2	24.3	27.2	64.6	60.6
Plastic Products	3.0	5.0	25.4	25.0	71.6	70.1
Rubber Products	4.1	4.4	19.8	20.5	76.2	75.1
Nonmetallic Mineral Products	8.3	7.4	22.4	23.3	69.3	69.3
Steel	10.8	12.9	25.0	19.8	64.2	67.2
Nonferrous Metals	4.3	3.9	29.2	28.0	66.5	68.1
Fabricated Metal Products	2.3	4.7	16.1	22.0	81.6	73.3
Nonelectric Machinery	3.9	4.7	21.0	22.2	75.0	73.1
Electric Machinery	4.1	4.3	18.7	19.2	77.2	76.5
Communications and Electronics Equipment	3.9	4.2	18.5	19.3	77.6	76.5
Other	4.7	4.5	19.0	19.0	76.3	76.5
Transportation Equipment	4.1	3.8	13.4	13.1	82.5	83.1
Motor Vehicles	3.9	3.5	11.8	11.3	84.2	85.2
Other	5.3	5.6	24.3	24.7	70.4	69.7
Precision Machinery	4.3	3.4	22.2	24.3	73.5	72.3
Other	4.2	3.4	22.1	22.5	73.7	74.1
Transportation, Communications and Utilities	5.5	5.9	32.1	34.9	62.4	59.3
All Industry Average	6.4	6.4	21.5	21.8	72.2	71.8

Source: Management and Coordination Agency, *Report on the Survey of Research and Development*.

their intellectual property rights more aggressively with respect to foreign competitors, and many lucrative relicensing agreements have been publicized over the past year. It is not clear, however, if this business strategy is the cause of the divergence between the value of old and new technology agreements.

The divergence between import cases and values has several anomalies (see Table 13). While the electronics sector's technology balance slipped further into deficit in both number of transactions and value, the average values of imports dropped in FY 1990, as did that of exports. In the publishing and printing industry, which accounted for most of the increased technology inflow, the number of import agreements soared, although the value of the deals rose only marginally. In general, the manufacturing sector, which naturally accounts for the bulk of technology trade, was a net importer in both numerical and value terms in FY 1990 and accounted for most of the gain in overall imports.

On the export side only slightly more industries exported technology in FY 1989 than FY 1990 (14 versus 12 specific categories), but the values of exports generally rose in more cases. Notably, the steel industry slackened its technology exports in FY 1990, as did the textile, fabricated metal products and precision machinery industries. Export boosters included the motor vehicle and the chemicals industries.

Table 11: Japan's Technology Exports, FY 1975-FY 1990

(number of approved cases and value in billions of yen)

	Cases		Value	
	Total	Of Which New:	Total	Of Which New:
FY 1975	2,811	1,073	¥66.6	¥18.9
FY 1980	4,103	1,237	159.6	74.3
FY 1985	5,885	2,099	234.2	73.3
FY 1986	5,469	1,730	224.1	51.8
FY 1987	5,955	1,655	215.6	44.8
FY 1988	6,352	1,850	246.3	47.4
FY 1989	7,559	2,086	329.3	66.6
FY 1990	7,163	1,570	339.4	58.6

Source: Management and Coordination Agency, *Report on the Survey of Research and Development*.

Table 12: Japan's Technology Imports, FY 1975-FY 1990

(number of approved cases and value in billions of yen)

	Cases		Value	
	Total	Of Which New:	Total	Of Which New:
FY 1975	6,766	796	¥169.1	¥13.3
FY 1980	7,248	919	239.5	27.7
FY 1985	7,679	1,245	293.2	33.3
FY 1986	7,494	1,141	260.6	33.6
FY 1987	7,373	813	283.2	56.2
FY 1988	8,356	1,382	312.2	54.6
FY 1989	7,109	1,056	329.9	48.4
FY 1990	8,249	956	371.9	73.4

Source: Management and Coordination Agency, *Report on the Survey of Research and Development*.

The pattern of technology trade by country (see Table 14) followed traditional lines in FY 1990, with a few notable points. Exports of Japanese technology to Asian nations continued to represent the bulk of activity on this side of the ledger. Although exports to China and South Korea dropped, those to Taiwan, Thailand and Indonesia continued to show solid gains. Exports to the United States and Western Europe were off or flat but, together, still accounted for about 31 percent of Japanese technology export transactions and 43 percent of their value.

Table 13: Japan's Corporate Technology Trade by Industry, FY 1989-FY 1990

(number of cases and value in billions of yen)

	FY 1989				FY 1990			
	Exports		Imports		Exports		Imports	
	Cases	Value	Cases	Value	Cases	Value	Cases	Value
Agriculture	5	¥0.0	1	¥0.0	4	¥0.0	10	¥0.0
Mining	9	0.0	27	0.3	15	0.8	9	0.7
Construction	219	12.4	290	2.0	286	16.9	166	1.8
Manufacturing	7,286	316.2	6,776	326.9	6,821	320.7	8,035	368.3
Food Products	142	8.3	93	8.5	165	8.0	94	8.6
Textiles	358	4.6	95	4.8	105	3.9	75	4.7
Pulp and Paper	36	0.6	21	1.3	37	1.0	21	0.5
Publishing	33	0.4	91	1.6	34	0.5	1,287	2.6
Chemicals	1,297	53.6	942	56.9	1,359	58.2	1,096	54.0
Synthetic Fibers	610	29.5	473	23.2	611	27.7	482	21.0
Fertilizers	253	3.8	136	5.0	267	3.8	317	3.6
Pharmaceuticals	317	18.9	252	21.5	385	25.0	247	22.5
Other	117	1.5	81	7.2	96	1.7	50	6.9
Petroleum and								
Coal Products	14	0.5	113	3.8	20	0.2	86	3.3
Plastic Products	94	1.2	89	1.3	89	1.1	87	2.2
Rubber Products	174	4.8	108	3.8	121	5.1	101	4.5
Nonmetallic Mineral								
Products	252	9.0	174	4.1	300	11.9	206	3.9
Steel	551	21.6	320	4.8	360	9.4	309	6.5
Nonferrous Metals	267	7.1	221	10.7	241	7.2	173	13.9
Fabricated Metal Products	409	2.0	154	2.3	223	2.4	150	2.4
Nonelectric Machinery	777	13.2	1,270	33.0	772	14.4	1,077	30.5
Electric Machinery	1,669	86.7	1,825	120.6	1,693	97.0	1,917	159.9
Electronics	980	58.5	1,376	92.0	1,018	67.7	1,500	122.4
Machine Tools	689	28.2	449	28.5	675	29.4	417	37.4
Transportation Equipment	777	87.1	819	54.9	971	92.0	826	52.3
Motor Vehicles	525	83.0	250	7.2	729	88.9	254	7.6
Other	252	4.1	569	47.7	242	3.1	572	44.8
Precision Machinery	320	12.6	290	8.3	224	4.3	367	11.4
Other	116	2.9	151	6.3	107	3.9	163	7.0
Transportation, Com-								
munications and Utilities	40	0.6	15	0.7	37	0.8	29	1.2
Total	7,559	329.3	7,109	329.9	7,163	339.4	8,249	371.9

Source: Management and Coordination Agency, *Report on the Survey of Research and Development*.

Table 14: Japan's Corporate Technology Trade by Country, FY 1987-FY 1990

(number of cases and value in billions of yen)

a. Exports

	FY 1987		FY 1988		FY 1989		FY 1990	
	Cases	Value	Cases	Value	Cases	Value	Cases	Value
Asia	3,152	¥86.4	3,264	¥101.4	3,965	¥128.9	3,887	¥153.3
China	405	9.4	339	8.4	473	8.1	307	6.8
Taiwan	590	12.3	660	13.2	609	16.3	722	15.7
South Korea	816	27.5	888	30.6	1,350	38.5	1,129	46.5
Thailand	294	7.3	331	9.9	364	17.6	406	24.6
Philippines	133	2.0	n.a.	n.a.	n.a.	n.a.	108	2.4
Indonesia	182	3.2	228	13.6	304	10.9	468	19.7
Malaysia	147	3.1	128	4.0	221	6.3	209	7.2
India	182	3.2	211	5.4	245	6.2	204	5.6
West Asia	52	1.6	59	2.3	72	2.4	61	2.0
North America	1,058	72.5	1,225	77.0	1,671	115.1	1,417	108.1
United States	912	65.9	1,080	71.1	1,445	107.7	1,250	99.5
South America	198	4.5	195	4.4	182	4.6	200	2.9
Brazil	107	2.5	114	2.5	n.a.	n.a.	n.a.	n.a.
Europe	1,184	40.3	1,281	49.3	1,342	65.1	1,275	61.5
Great Britain	190	10.6	221	13.9	251	20.0	236	20.1
West Germany	297	7.4	301	10.7	328	13.7	323	11.7
France	162	5.2	137	4.4	149	7.1	149	9.4
Netherlands	53	2.1	86	2.2	71	2.1	63	1.8
Switzerland	52	2.3	63	1.4	51	1.6	53	1.7
Africa	147	5.0	141	6.0	136	6.8	137	6.3
Oceania	164	5.3	187	5.9	191	6.5	186	5.2
Australia	116	4.2	134	5.2	143	5.7	147	4.6

b. Imports

	FY 1987		FY 1988		FY 1989		FY 1990	
	Cases	Value	Cases	Value	Cases	Value	Cases	Value
Asia	12	¥0.1	29	¥0.2	26	¥0.3	18	¥0.2
China	2	*	0	0.0	3	*	2	*
Taiwan	2	*	15	0.0	4	*	1	*
South Korea	4	*	4	*	7	0.1	6	0.0
West Asia	2	*	0	0.0	8	0.1	10	0.1
North America	4,747	179.3	5,591	198.1	4,118	210.7	4,427	257.9
United States	4,667	178.6	5,495	196.9	4,029	209.5	4,332	255.3
South America	3	*	1	*	1	*	0	0.0
Europe	2,568	103.4	2,706	113.6	2,903	118.2	3,757	112.8
Great Britain	512	10.3	451	9.3	487	10.8	889	9.9
West Germany	847	21.4	835	18.4	1,104	24.3	1,258	27.0
France	313	22.1	432	26.2	354	25.5	324	22.8
Netherlands	173	20.8	182	27.6	202	21.1	200	20.2
Switzerland	273	17.4	277	18.4	256	19.0	635	15.3
Africa	3	*	0	0.0	0	0.0	1	*
Oceania	38	0.3	29	0.3	53	0.7	36	1.0

*Less than ¥50 million.

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

The United States remained the largest single source of technology in FY 1990, but the 4,332 cases was well below the record high of 5,495 set in FY 1988. Imports of know-how from Western Europe grew steadily in number from FY 1987 through FY 1989 and then leapt nearly 30 percent in FY 1990, although their value actually dropped between FY 1989 and FY 1990. West Germany, Great Britain and Switzerland supplied most of the increase. An expanded Japanese presence on the continent in preparation for the European Community's economic integration may be a major reason for the volume of Japanese activity.

Tokyo's pledges to bear greater international responsibilities notwithstanding, areas outside Asia and the developed world have continued to receive scant attention from Japanese companies in terms of technology transfer, according to FY 1990 data. Technology exports to West Asia, South America and Africa showed little progress either that year or in the FY 1987-1989 period. There are few signs that this situation will change. But, because the data reflect only corporate technology trade and ignore government efforts, the level of Japanese technology transfer to these areas likely is understated.

Progress Toward New Goals

The debate in Japan over the nation's new international responsibilities has pushed Tokyo to revise its goals for R&D; this overhaul already is bringing about changes in policies and spending. At present Tokyo has enumerated four areas of concentration: fostering basic research; focusing on environmental issues; transferring technology to developing countries; and internationalizing its R&D system. These four goals often intertwine, sometimes creating positive synergy but also generating problems. Japanese aid officials, for example, are interested in transferring to developing nations technology that not only will make economic sense but environmental sense as well. Moreover, several of Tokyo's proposals for joint international research (applied and basic) have generated controversy overseas as well as within the Japanese government.

- **Environmental Considerations** - The previous discussion of government R&D spending by agency has shown a number of projects with a "green" theme. New projects continue to crop up, many with dual purposes. MITI, for example, is exploring ways to reduce emissions of exhaust gases from internal combustion engines in a way that also increases fuel efficiency. These exhaust gases are so-called greenhouse gases, which the government has pledged to limit. Another dual-purpose project is exploring methods of refrigeration and cooling that do not rely on chlorofluorocarbons that are said to harm the earth's protective ozone layer. Nevertheless, it still is not clear exactly how much "new" money is being spent on environmental projects and how much simply covers "old" projects with a coating of green.

- **Technology Transfer** - Japan has developed many technologies, such as small-scale manufacturing and energy systems, well-suited to developing countries because they do not require sophisticated maintenance or inputs not available locally. One of the biggest obstacles to a greater flow of technology from the Japanese government to developing countries is not a scarcity of relevant know-how but a lack of human/administrative resources to distribute the aid. Foremost, Japan's foreign aid program is understaffed (see *JEI Report* No. 45A, December 6, 1991). An increase in training programs in Japan has bolstered technology transfers (see *JEI Report* No. 7A, February 21, 1992), but progress remains slow in Tokyo's efforts to encourage corporate Japan to boost technology transfers to poor developing countries.

- **Basic Research** - This is another area where Tokyo's rhetoric is ahead of reality, although the gap is closing. Aggregate spending data show little change, so far, in the division of Japan's R&D pie among basic, applied and developmental research. Outlays for basic R&D programs, such as the Human Frontiers Science Project — which explores basic body and brain functions, are expanding at a healthy pace. Moreover, initial budget requests for FY 1993 indicate that the Ministry of Education remains intent on upgrading the nation's university laboratories.

A point worth raising is that the meaning of "basic" research is different in Japan than it is in the United States or Europe. Japanese basic research often is aimed at finding basic uses for products, not at developing an understanding of the fundamental science that lies behind a particular phenomenon. Japanese scientists and science policy planners are debating this difference, but it is unlikely that the Japanese definition will move much closer to the American or European standard. In fact, the Japanese see their interpretation of basic R&D as something they can contribute to the world precisely because it often does lead to tangible benefits.

- Internationalization of Japanese R&D - Not only does internationalization imply external ties to foreign research resources and a research presence overseas but invitations to foreigners to engage in or become aware of work within Japan as well. Internal efforts include: the promotion of activities for foreign researchers in Japan, wider dissemination of Japanese research and the elimination of distinctions between Japanese and foreign research activities, at least insofar as government calls for bids. Politics, both domestic and international, plays an inordinately large role in this area, causing problems and obstacles more often than not.

- Human Frontiers Science Program - This well-established project exploring the basic biochemical functioning of the human brain and body is attracting research grant applicants from around the world. While both STA and MITI boosted program funding this year, the number of researchers and funded projects has reached expected levels; funding is likely to plateau as a result.

- Human Genome Project - Proposed by American scientists in 1985, HUGO aims to map the genetic information of 30 individuals over the next 15 years at a cost of about \$3 billion. Tokyo's response continues to be lukewarm. While STA has budgeted about \$8 million for the project, other agencies have shown little interest.

- Superconducting Super Collider Project - The SSC will use an unprecedented number of superconducting magnets to smash protons together in an effort to understand the fundamental nature of matter and energy. The giant accelerator will cost an estimated \$8.5 billion (\$11 billion by private estimates), for which Washington hopes to get foreign coverage of one-third. Japan and other allies have been approached to contribute in exchange for access to the facility. The recent House of Representatives' vote to cease funding the SSC has decreased the likelihood that Tokyo can be coaxed to join.

- Intelligent Manufacturing System - First proposed by MITI in late 1989, IMS is a universal computer standard to handle the design, production and distribution of goods. MITI invited American and European companies to participate, but Washington and Brussels insisted that the project be handled at the government-to-government level. After more than two years of talks, the three sides are moving to begin cooperation in limited areas, such as communications specifications. Many details remain to be worked out, and IMS likely will go forward in a form far different from what Tokyo originally envisioned.

- Real World Computing Project - MITI envisioned this successor to its much-heralded "Fifth Generation" computer project as a multinational affair. It also has become a topic of government-to-government negotiations that have stretched its time horizon. As with IMS, Washington and Tokyo have agreed to limited cooperation on specific research topics as a test case before proceeding with full-fledged joint research. The first pilot topic is a test module for evaluating optoelectronic components.

- Government-Industry Joint R&D - To encourage foreign participation Tokyo liberalized the rules for joint research projects, with particular attention paid to an equitable sharing of resultant intellectual property rights. After an initial rush in FY 1991, however, foreign interest in new public-private research projects has cooled. It may be that foreign companies are waiting to join pending their evaluation of the experiences of foreign firms that already have signed up for projects.

- Private Efforts - Faced with the twin challenges of path-breaking basic research and a dwindling supply of Japanese scientists, Japanese companies are adopting a global view for their research efforts. Foreign scientists and engineers are being hired under short- and long-term conditions to staff and lead domestic projects. At the same time some firms are setting up R&D centers overseas with both local and Japanese staffing. While the numbers still are small, Japan's corporate R&D community is becoming more internationalized.

"Technoglobalism"

This Japanese-coined term, which describes the next stage of Japan's R&D establishment, encompasses the erosion of national borders with regard to scientific and technical research as well as cooperative, mutually beneficial R&D links among companies and governments. The confluence of four factors has made "technoglobalism" the buzzword for 1992 in Japan's science policy community. Two of the four factors — increasing foreign pressure on Japan to make a positive contribution to global science and technology in addition to the increasingly global scope of Japan's R&D programs — already have been outlined. The remaining two are:

- A reevaluation of the "no holds barred" attitude of Japanese companies toward competition (see *JEI Report* No. 15A, April 17, 1992). Highly competitive Japanese companies have won major shares of markets, generating foreign resentment and protectionist backlashes overseas. Japan's business community is debating whether this dogged competitiveness remains appropriate in today's post-Cold War economic environment. Key business leaders and business groups have called for a more cooperative *modus vivendi* between Japanese and foreign companies. Keidanren (Japan Federation of Economic Organizations), Japan's leading business association, has labeled this "kinder and gentler" business behavior "symbiosis." Cooperative research between Japanese and foreign firms is a key component of this new attitude.

- The current Japanese economic downturn has shaken the confidence of many Japanese companies in their ability to survive independently in the increasingly competitive global economy. Falling profits, increasing capital costs, stumbling domestic equity markets and rising research, product-development and manufacturing costs and risks have made strategic alliances and joint R&D projects with foreign firms much more attractive to Japanese companies.

In many ways the private sector has been pursuing "technoglobalism" for decades without any encouragement from the government. Fuji Photo Film Co., Ltd. and Xerox Corp. plus Hewlett-Packard Co. and Yokogawa Electric Corp. long have had productive joint ventures. Even joint ventures of recent vintage are announcing positive results, indicating cooperative rewards without decades-long relationships. International Business Machines Corp. and Toshiba Corp., for example, have codeveloped and are manufacturing active-matrix liquid-crystal display screens for laptop computers. By pooling their financial and technical resources, the two partners have raised output yields of the difficult-to-make displays to the 50 percent-range, according to Japanese press reports. Among the industries in the midst of restructuring with the global marketplace in mind:

- The Japanese, American and European automotive industries increasingly have become intertwined via joint development, design, production and research agreements. Many analysts predict that the global industry will undergo a major consolidation in the next decade as national markets are liberalized and production becomes internationalized.

- Electronics and computer companies also are becoming less concerned with national borders and more focused on the global marketplace. In recent months foreign and Japanese companies once considered archrivals have announced joint research, development and production agreements. The rapidly escalating costs of developing new generations of microchips and building production facilities are propelling companies to pair up. Many analysts expect future competition to be between multinational groups of companies rather than between groups of firms from one country.

- The emerging field of multimedia has taken on an international cast. Japanese companies are offering their hardware expertise in combination with foreign firms' software know-how to get in on the ground floor of this new industry, which seamlessly melds digital sound, text, graphics and video.

MITI has welcomed the growing internationalism of the Japanese business community but wants to ensure that the nation's scientific community is drawn into the process. This year's industrial technology white paper and several advisory bodies have examined the meaning of "technoglobalism" with regard to government R&D policies. Along with encouraging and

accommodating international alliances among firms, the main thrust of this exercise is Tokyo's preparation to contribute to the globalization of science by supporting Centers of Excellence in Japan and abroad. These centers would support leading-edge basic and precommercial research by funding grants, support staff, laboratory facilities and housing. The COEs would foster the exchange of ideas amid many scientific disciplines and among researchers from around the world.

While the goals of COEs look worthwhile on paper, many practical problems impede its realization. MITI's outline does not clearly specify which agency will control the centers, how they will be funded and where they will be located. The Ministry of Education, which is trying to strengthen the national university system to become a "center" of topflight basic research, almost surely would have trouble with MITI's plan. Given the poor reception by foreigners of previous MITI initiatives aimed at international participation, foreign official support for COEs is not likely to be enthusiastic, at least at the outset. The political nature of these problems and other logistics cloud the future of "technoglobalism."

Conclusion

The well-funded, vigorous Japanese research effort ensures that Japanese industry will remain internationally competitive well into the next century. Japanese research policies do not exist in a vacuum, however, and fundamental changes in the global economic and political environment are driving realignments. As an important component of its bid to bear greater international responsibilities, Tokyo has pledged that Japan will become a net contributor to the world's storehouse of basic and applied knowledge. The small steps in this direction, as reflected by changes in government and private research budgets, show that this pledge will be achieved — but only over a long period of time.

Equally important to the success of Tokyo's campaign is the attitude of foreigners toward Japanese cooperative research initiatives. If Tokyo's multinational projects continue to be met with skepticism and suspicion (whether or not it is deserved), Japan will be unable to carve out a larger international role for itself. Similarly, Tokyo's response to multilateral initiatives from overseas has an important impact on the climate surrounding Japan's effort to play a more active international role.

While Tokyo debates policy, domestic companies also are debating new directions in R&D. Intensifying global competition combined with greater financial and technological risks are driving Japanese companies to reconsider their business priorities. One result of this reevaluation is a growing number of R&D partnerships with foreign firms, the first concrete signs of a trend toward "technoglobalism." Development of this trend could either mute or exacerbate the frictions over high technology that currently plague Japanese commercial and political relations.

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The views expressed in this report are those of the author and do not necessarily represent those of the Japan Economic Institute.